Comment on "The dead zone for string players"

In a recent Letter Broomfield and Leask[1] experimentally found that "It is not possible to produce sound from a string when it is bowed at its midpoint." This finding is trivial if one knows the following mechanism of bowing:

It is well known[2] that if one puts a horse-tail bow hair under a microscope, there are many 'small nails' on its surface. It is these 'nails' which continuously pluck the string as the bow moves that produce sound. This is different from what happens when one plucks a string with one's finger. In the latter case the string can vibrate freely once the finger has left the string, while in the former case the fingers constantly intervenes the vibration. The nail spacing is so close, perhaps it is better to describe these 'nails' as 'brushes' or 'combs'. This kind of vibration is therefore better described as a 'forced' or 'kicked' vibration. Once one nail has passed over the string, the string can only vibrate freely for a short period before the next nail arrives. It is therefore better for the amplitude of vibration at the bowing point to be about the same as the spacing of the nails so that the intervention of the nails is minimized. If the amplitude is larger than the spacing of the nails, the string does not manage to vibrate much before the next nail arrives.

There are already mass-and-spring models for bowing of string instruments in the literature[3]. Generally, they consider bowing as a *macroscopic* frictional effect. These friction-like models will have difficulty to explain the silence of bowing in the middle of the string. However, with the *microscopic* mechanism proposed here the phenomenon is clear.

This mechanism applies to every part of the string, but the influence of the next nail becomes most significant as one bowes at the midpoint. Furthermore, the mechanism has nothing to do with the resin used. Resin increases the friction, or the length and the number of the nails. A clean bow without any resin can still produce sound.

More refined models can be developed based on the reasoning given above. It will be interesting to find out experimentally what kind of modes are excited at different bowing conditions. Remember that the string is not a rigid body and the nails do not always pluck the string in a direction normal to it. Therefore, the generation of the vibration and the interference of the next nail is always imperfect. In the field of nonlinear dynamics, phenomena of 'kicked oscillators', which display interesting chaotic behaviour, have been studied. It will also be interesting to see how they apply to the bowing of violins.

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[1] J. E. Broomfield and M. J. M. Leask, Eur. J. Phys. **20** (1999) L3.

[2] R.E.Fryxell, Catgut Acoustical Society Journal, November (1973); F. Rocaboy, ibid, November (1990) 34; R.E.Menzel, R. Marcus, Catgut Acoustical Society Newsletter, November (1979) 14. E. G. Gray, Strad, **82** (1989) 107.

[3] N. H. Fletcher, Rep. Prog. Phys., **62** (1999) 723.

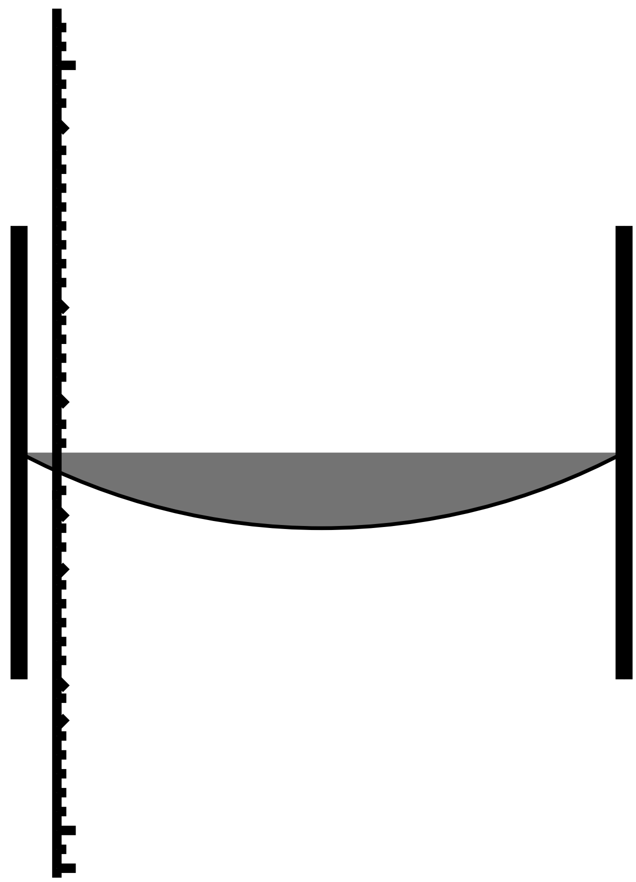

FIG. 1. Schematic plot of bow-hair string interaction. Bowing a string is just like sawing it. The sound generating mechanism is something in-between plucking a string with one's finger and microscopical frictional effects. One should consider the process as a kicked vibration. The presence of the next nail will stop the vibration if one bows at the middle of the string.